An Integrated Pest Management Approach: Monitoring Strawberry Pests Grown under Protected Structures

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Abstract

Integrated Pest Management (IPM) is a holistic approach to pest control in which various pest management practices are implemented, some even before planting the crop. These practices may include sanitation, the use of transplants with reduced associated pests, chemical and biological methods, and generally sound cultural practices. A well-developed management plan is in place for pests such as the two spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae). The elements of the plan for mite control include the use of high quality transplants and the release of predatory mites at predetermined thresholds. The cotton aphid, *Aphis gossypii* Glover (Homoptera: Aphididae), is controlled by means of regular releases of parasitic wasps. The current study was initiated to monitor the population dynamics of natural infestations of the cotton aphid on strawberries grown in a glasshouse in north central Florida and to evaluate the effectiveness of the predator *Coleomegilla maculata* DeGeer to control aphids. This study suggests that early detection of pests and early intervention result in an effective control.

INTRODUCTION

Florida is one of the top strawberry producing states in the U.S. It ranks second in harvested area, total yield, and production only after California (USDA-FAD, 2001-2002). The Florida strawberry industry produces during the winter months of November through March in the field and high quality production during these months is the key to maintaining profitability. One alternative to increase strawberry earnings is greenhouse production. Growing strawberries under protective structures has become a viable alternative for strawberry producers that could enhance winter strawberry production. Some of the advantages of greenhouse production are the avoidance of soil fumigation, the reduction of fungal and bacterial diseases, and reduced water use.

The twospotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae), is a major pest of strawberry in the greenhouse as well as in the field (Howard et al., 1984). Success has been achieved in reducing the threat from this pest in the field by the introduction of *Phytoseiulus persimilis* Athias-Henriot onto the strawberry crop when about 5-10% of the strawberry leaflets have been infested with one or more mites (Van de Vrie and Price, 1994).

Another recurrent pest in greenhouses is the cotton aphid, *Aphis gossypii* Glover, a major pest of cotton and other crops worldwide (Leclant and Deguine, 1994). This small, soft-bodied insect feeds on the underside of leaves sucking out plant sap. Aphids vary in color and size (Watt and Hales, 1996); spring populations can be darker and may be twice the size of “yellow dwarfs” present in the summer (Nevo and Coll, 2001). High populations of aphids can reduce the vigor of the plant making it susceptible to other pests. The honeydew that aphids excrete can reduce fruit quality because of the development of a black sooty mold on the substrate. This sooty mold reduces the photosynthate production and otherwise reduces the quality of the plant.

Natural enemies are important in the control and regulation of the cotton aphid, moreover, any factor affecting parasitoids, predators or other biological control could cause economic damage to the crop (Kaplan and Eubanks, 2002). Natural enemies effective against the cotton aphid reported in the literature include lady beetles

(*Coccinella septempunctata* L. and *Hippodamia convergens* Guerin-Meneville), the green lacewing (*Chrysoperla carnea* Stephens), and wasps (*Lysiphlebus testaceipes* (Cress) and *Aphidius colemani* L.) (Howard et al., 1985; Van Driesche and Bellows, 1996; Kaplan and Eubanks, 2002). The pink spotted lady beetle, *Coleomegilla maculata* DeGeer, also is known to feed on the cotton aphid (Rondon et al., 2004); however, the role of *C. maculata* in the strawberry ecosystem is relatively unknown. This polyphagous predator is abundant in herbaceous crops such as maize (*Zea mays* L.), alfalfa (*Medicago sativa* L.), and potato (*Solanum tuberosum* L.) where *C. maculata* feeds on various prey (Gordon, 1985; Krafsur and Obrycki, 2000).

The current study was initiated to monitor the population dynamics of natural late-fall early-spring infestations of the cotton aphid, *A. gossypii*, on strawberries grown in a glasshouse in north central Florida and to evaluate the effectiveness of *C. maculata* 3rd instar on controlling aphids.

MATERIALS AND METHODS

Study Site and Strawberry Production

The seasonal population dynamics of the cotton aphid was monitored in strawberries grown in a glasshouse at the University of Florida (UF), Horticultural Sciences Department. Strawberry plants were produced at the UF Horticultural Sciences Department following the protocol of Paranjpe et al. (2003). The following exceptions were made; after cutting the runners from mother plants, 'Sweet Charlie' strawberry plugs were grown in the greenhouse using a low-mist fertigation system. Four trays of 80 plugs per tray were set on a 1 peat : 1 Perlite mix media. Plugs were exposed to a 2 week chilling period in the growth chamber before transplanting at 25 ± 2 ^{o}C and 10 ± 2 °C day and night temperature, respectively, with a 9 h photoperiod. After the chilling period, plugs were transplanted to 1.9-liter plastic pots using soilless media (2 Peat : 1 Perlite mix). Forty rows of four pots per row were arranged on top of an 8 m long metal bench. Monitoring started when four fully developed leaves appeared. A weekly rotation of Quadris® 2.08F azoxystrobin at 275 g active ingredient/ha and Nova® 40W myclobutanil at 142 g active ingredient/ha spray was made as necessary for preventing powdery mildew, the main disease in strawberry greenhouse production.

Aphid Sampling Methods

Aphid populations were monitored twice weekly from 28 January to 20 May 2002. The experimental design was a randomized complete block with four replications. Each replication consisted of 20 plants from which five plants per replication were randomly selected. Six rows of strawberries separated each block. Each strawberry pot sampled was considered an experimental unit. No insecticide was used at any time during the investigation. The total numbers of apterous and alate adults and nymphs were counted *in situ* from the developing bud and from the middle strawberry leaflet of one plant with the aid of a 5X lens. Nymphs and "dwarf" forms were discriminated from the adults based on the short cauda plate present at the tip of the abdomen in the immature stages as compared with a long cauda present in the adult form (Blackman and Eastop, 2000).

Caged Greenhouse Trial

A functional response experiment was conducted to examine the effectiveness of *C. maculata* 3rd instar as a predator of the cotton aphid. *C. maculata* was obtained from Entomos LLC (Gainesville, FL 32608), a local insect supplier.

In a greenhouse, five clean strawberry plants were placed into a 1 m^3 nylon covered cage. Each five strawberry plants were infested with adult aphids and the leaf were the infestation was made was marked. Three cages of plants were infested with five aphids per plant, three cages were infested with ten aphids per plant, and three cages were infested with 15 aphids per plant. After 1 week the aphids on the labeled compound leaf per plant were counted. After counting was completed, one, three, of five 3rd instar *C. maculata* were released into the cages. The number of aphids consumed on the labeled leaf was counted weekly for 3 weeks. The experiment was repeated three times.

Data Analysis

Data were analyzed with SAS (SAS Institute, 2000). The general linear model (GLM) procedure was used to construct analysis of variance (ANOVA) for mean number of apterous and alate adult aphids and nymphs each year. Means were compared and separated *(P* = 0.05) by the least significant difference (LSD) test.

RESULTS AND DISCUSSION

Population Dynamics of Aphids on Strawberries

The average temperature in the greenhouse during the conduction of this experiment was 22:16 ^{O}C D:N temperature, respectively. Overall mean numbers of nymphs observed on leaves (5.09 $\pm$ 1.43) were greater than observed on the emerging bud (3.94 $\pm$ 1.25) (F = 26.34; df = 3, 12; *Pr* > 0.001). Nymph densities on the bud were highest 15 March (16.75 $\pm$ 5.46) (Fig. 1A) and then gradually decreased towards the end of the sampling period. Two peaks were observed on leaves 25 February (15.95 $\pm$ 4.33) and 15 March (14.5 $\pm$ 3.81) (Fig. 1A). Overall numbers of adults on the bud (8.29 $\pm$ 1.54) were greater than on the leaves (6.62 $\pm$ 1.56) (F = 18.34; df = 3, 12; *Pr* > 0.001). Adult densities on the bud were highest on 25 February (24.55 $\pm$ 5.32) and 15 March (39.65 $\pm$ 7.23) (Fig. 1B) and then gradually decreased towards the end of the sampling period. Two peaks also were observed on leaves 25 February (19.50 $\pm$ 7.23) and 15 March (17.55 $\pm$ 4.41) (Fig. 1B). Overall numbers of alate adults on the bud (0.29 $\pm$ 0.11) were greater than on leaves (0.03 $\pm$ 0.01) (F = 14.34; df = 3, 12; *Pr* > 0.001). In the bud, numbers were highest on 11 March (0.2 $\pm$ 0.1) (Fig. 1C). Two peaks were observed 11 March (3.00 $\pm$ 1.18) and 8 and 15 April (0.5 $\pm$ 0.2 and 0.5 $\pm$ 0.1) (Fig. 1C). Overall combined numbers of aphids on the bud (12.26 $\pm$ 2.80) were greater than on the leaves (11.99 $\pm$ 3.11). On the bud, combined numbers of aphids were highest on 15 February (24.65 $\pm$ 9.87) and 15 March (56.40 $\pm$ 11.35) (Fig. 1D). Two peaks also were observed on leaves on 25 February (35.50 $\pm$ 9.85) and 15 March (32.15 $\pm$ 8.15) (Fig. 1D).

Functional Response of *C. maculata* to Aphid Densities

One week after five aphids were released per plant, there was an average of 59.9 ± 12.6 aphids per strawberry leaf. One 3d instar *C. maculata* reduced 53.8, 36.2, 27.2 and 20.6 % of the aphid population after 1, 2, 3, and 4 weeks respectively (Fig. 2A). Three predators reduced 97, 28.6, 15 and 13.2 % of the aphid population 1, 2, 3 and 4 weeks respectively after being released (Fig. 2A). Five predators reduced 29, 5, 2.2, and 2.22 % of the aphid population 1, 2, 3, and 4 weeks respectively after being released (Fig. 2A).

One week after ten aphids were released per plant, there was an average of 77.7 ± 21.6 aphids per strawberry leaf. One 3rd instar *C. maculata* reduced 70.2, 11, 8 and 6.2 % of the aphid population after 1, 2, 3, and 4 weeks respectively (Fig. 2B). Three predators reduced 87.6, 12.6, 11 and 8 % of the aphid population 1, 2, 3 and 4 weeks respectively after being released (Fig. 2B). Five predators reduced 75.2, 22.8, 8.6, and 4.2 % of the aphid population 1, 2, 3, and 4 weeks respectively after being released (Fig. 2B).

One week after 15 aphids were released per plant, there was an average of 167.3 ± 28.4 aphids per strawberry leaf. One 3rd instar *C. maculata* reduced 46.2, 46.3, and 39.0 % of the aphid population after 1, 2, 3, and 4 weeks respectively (Fig. 2C). Three predators reduced 87.3, 35.4, and 23.4 % of the aphid population 1, 2, 3 and 4 weeks respectively after being released (Fig. 2C). Five predators reduced 96.4, 57.3, and 22.4 % of the aphid population 1, 2, 3, and 4 weeks respectively after being released (Fig. 2C).

DISCUSSION

Results from this experiment indicate different cotton aphid life forms predominate on different plant locations. Nymphs were more frequently found on a leaf than on the developing bud in the early season but that distinction does not persist later. Apterous adults predominated on the bud during the midseason while alate adults were more frequently found on a leaf during the same period. Understanding this can be important in developing monitoring and biological or chemical control strategies.

The greatest positive functional response of *C. maculata* to cotton aphid occurred when the prey was most dense (Fig. 2C). This is a characteristic of an efficient predator and indicates that *C. maculata* may be a good candidate for biological control of melon aphid on strawberry.

These studies have increased the understanding of the relationship among the strawberry, its cotton aphid pest and an important biological control agent and provide a basis for developing a biological control of melon aphid component of comprehensive integrated strawberry pest management program.

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Figures

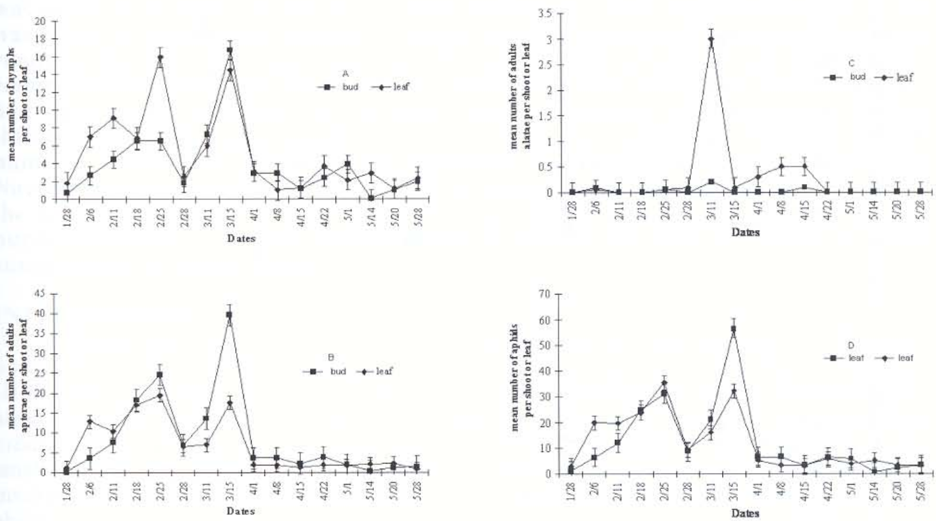

Fig. 1. Population dynamics of nymphs (A), apterous adults (B), alatae adults (c) and total (D) of *Aphis gossypii* Glover on strawberry grown in a greenhouse, 2002.

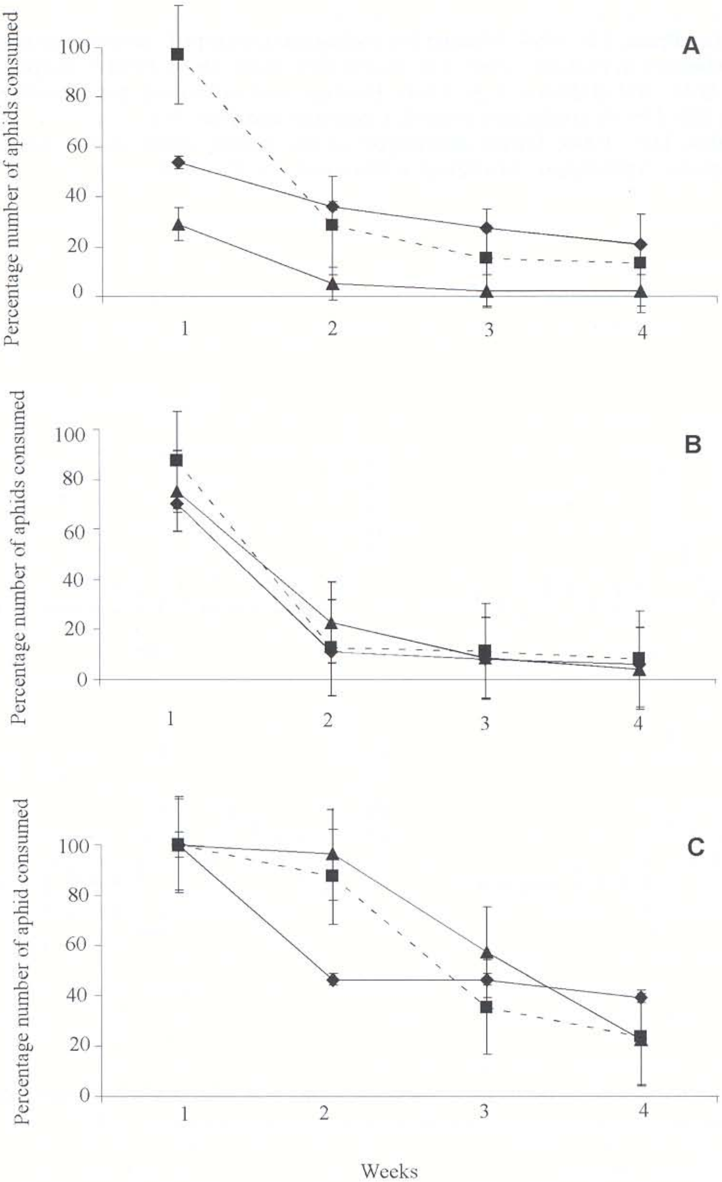

Fig. 2 Third instar *Coleomegilla maculata* DeGeer response to low (A), medium (B), and high (C) densities of the melon aphid, *Aphis gossypii* Glover.

—◆— 1 predator - ■ 3 predators —▲—5 predators